DURABILITY PERFORMANCE OF LIGHTWEIGHT CONCRETE CONTAINING PALM OIL FUEL ASH AS MIXING INGREDIENT

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B.ENG (HONS.) CIVIL ENGINEERING

UNIVERSITI MALAYSIA PAHANG

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the Bachelor Degree of Civil Engineering

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Malaysia adalah antara pengeluar dan pengeksport terbesar hasil kelapa sawit di dunia. Sejak kebelakangan ini, Malaysia mengalami kekangan dalam melupuskan hasil kepala sawit yang tidak digunakan . Hasil kelapa sawit yang terhasil and dibiarkan itu menyebabkan masalah pencemaran alam sekitaran. Ianya juga menjadi antara sebab ketidakseimbangan ekologi sekirangan dibiarkan tanpa kata putus.Oleh sebab itu, hasil kepala sawit telah digunakan dalam menghasilkan konkrit ringan dengan kadar peratus yang berbeza. Konkrit tersebut diuji ketahanan dalam larutan asid dan sulfat.Semua konkrit tersebut telah direndam dalam air selama 28 hari sebelum dimasukkan kedalam bekas yang mengandungi laturan asid selama 1800 jam. Selain itu, konkrit tersebut telah dibiarkan dalam cecair sulfat selama 16 minggu untuk menguji kadar kehilangan berat dan untuk mnguji kemerosotan kekuatan konkrit. Hasil daripada kajian ini, 20 % kadar peratus POFA menunjukkan ketahanan yang cemerlang terhadap kedua- dua keadaaan.

ABSTRACT

Malaysia as the world‘s largest exporter of palm oil has been facing problem in disposing palm oil fuel ash, a by- product of palm oil mill since years ago. The abundant production of waste material from palm oil plantation which disposed at landfill will cause environmental degradation and it is harmful to the ecosystem or ecological imbalance if there is no proper action taken to reduce it. This research investigates the durability of lightweight concrete containing various percentage of POFA replacement when subjected to acidic and sulphate environment. All the specimens were subjected to water curing for 28 days before immersed in the hydrochloric solution having pH 2 for 1800 hours. The specimens also being subjected to sodium sulphate solution for 16 weeks. The strength deterioration was evaluated through mass changing of the specimens and compressive strength determinations. The finding shows that 20% of POFA replacement enhances the resistance of lightweight concrete towards acid attack and sulphate attack.

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF SYMBOLS

%	Percentage
mm	Millimetre
mm^2	Millimetre square
m^3	Cubic meter
μm	Micro meter
g	gram
kg	Kilogram
MPa	Mega Pascal
kN	Kilo newton
°C	Degree Celsius
°	Degree
A	Area
P	Maximum load carried by specimen during testing
fc	Compressive strength of concrete specimen
d	Depth

LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
BS	British Standard
C-S-H	Calcium Silicate Hydrate
CaO	Carbon Oxide
HCI	Hydrochloric Acid
OPC	Ordinary Portland Cement
POFA	Palm Oil Fuel Ash

CHAPTER 1

INTRODUCTION

1.1 Introduction

Concrete is one of the composite construction material that composed of a coarse granular material, the aggregate or filler that embedded with water and cement. Each of concrete possesses their own unique characteristic to meet the suit the needs of the construction industry. Concrete plays a key role in the construction field for making a various structure such as architectural structures, pavement, bridges, and others. It is also being used in oil production field to construct the massive off-shore platforms for drilling and production activities. Continues research and development of concrete have contributed to the production of various types of concrete over years to provide more alternative construction materials. Therefore, one of the concrete that popularly increases drastically in recent year is lightweight concrete. Lightweight concrete is the predominant materials being used in the construction field and it is known as aerated concrete in European countries due to its versatilities and lightness, which has brought a new image of application of Malaysia building Technology.

Lightweight is mainly depending on the concrete density. This is because using of lightweight concrete in construction field which possess low-density property that contributes towards the reduction of building and resulting in more economical structural design (Narayanan and Ramamurthy, 2008) .It is react as reducing of the dead load may consequently the decreasing of size of bearing load capacity. Lightweight concrete can be classified into low density natural aggregate concrete, synthetic aggregate concrete, and cellular or aerated concrete and high performance lightweight concrete. The practical range of concrete density for lightweight concrete is between 320kg/m^3 and 1850 kg/m^3 (Neville, 2006). Besides, lightweight concrete is

good in thermal insulation properties and fire resistance, where it has a lower thermal conductivity which is a very important aspect in the construction field.

Malaysia is well known for palm oil industries and is one of the largest palm oil producers and exporter in the world **(**Mannan, 2008). In 2006, Malaysia had produced 17.7 millions tons of palm oil on 4.5 million hectares of land, (Muthusamy *et al.*, 2015). Because of that, these industries generate a lot of abundant waste product annually during palm oil processing and these waste products are simply disposed of without commercial return of (Mannan and Ganapathy, 2002). The larger amount of waste product from palm oil industry is not being reused and dumped in the landfill. In this scenario, it is predicted that larger amount of palm oil waste would be discarded as environmental pollution waste in the future. Therefore, oil palm waste had been chosen in research as new concrete material in order to convert environmental pollution problem into beneficial for the development of human civilization in the future.

1.2 Problem Statement

The cement industry is one of the well-known industries in Malaysia. The cement industry produces carbon dioxide which can cause greenhouse gas effect. Almost 4- 5 % of worldwide of a total of carbon dioxide gas is released during the production of cement. The released of carbon dioxide gas during the production of cement cause a lot of environmental problem to a human being and other habitants.

With around 40 % of total world supply in the years of 2008 to 2010, Malaysia is known as the second largest palm oil producer in the world (Altwair *et al.*, 2012). The abundant production of waste material from palm oil plantation will cause environmental degradation and it is harmful to the ecosystem or ecological imbalance if there is no proper action taken to reduce it. This waste product is normally disposed of through incineration whereby it is hard to dispose of easily. It is light which easy to be blown by the wind and spread to another place thus causing air pollution. The disposal of palm oil waste causes a negative effect on the health and comfort of the community (Tay and Show, 1995). More than 5 % of palm oil fuel ash (POFA) is left behind after the operation (Jamo, 2015). Due to the deficiency in nutrients as the fertilizers plus the underutilization of POFA, it is then disposed as waste in landfill

(Islam *et al*., 2014).Because of this, the government has to assign more hectares of land for huge waste disposal, which leads to further financial losses incurring from necessary transportation and maintenances. While, the high demand for cement and coarse aggregate in concrete, it causes this non-renewable resources depleting in the future generation.

1.3 Objectives of Study

The main objectives of this study were to study the durability of lightweight concrete containing palm oil fuel ash as mixing ingredients. The objectives of this research were as follow:

i. To investigate the effect of POFA content on compressive strength of lightweight concrete for 28 and 90 days.

ii. To investigate the acid performance of lightweight concrete containing POFA.

iii. To investigate the performance of lightweight concrete containing POFA when exposed to sulphate environment.

1.4 Scope of Study

This study concentrates on the performance of lightweight concrete containing palm oil fuel ash in terms of compressive strength, acid resistance and sulphate resistance. In the first stage of laboratory work, a mix proportion for lightweight concrete of grade 30 was developed using trial and mix method. Then, three series of concrete mix with finely ground POFA as part of mixing ingredient was composed of an unconventional mix comprises 0 %, 20% and 40 % of the total weight of cement. This mixes were prepared in form cubes and water cured for 28 days.

The acid resistance of lightweight concrete with POFA is evaluated by measuring the mass loss and strength reduction of the samples after immersed in hydrochloric solution. The durability of lightweight concrete containing POFA against sulphate

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